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Demonstration of GREET1.7 Simulations

III. Uncertainty Analysis with Stochastic Simulations

Ye Wu

***Center for Transportation Research
Argonne National Laboratory***

***GREET User Workshop
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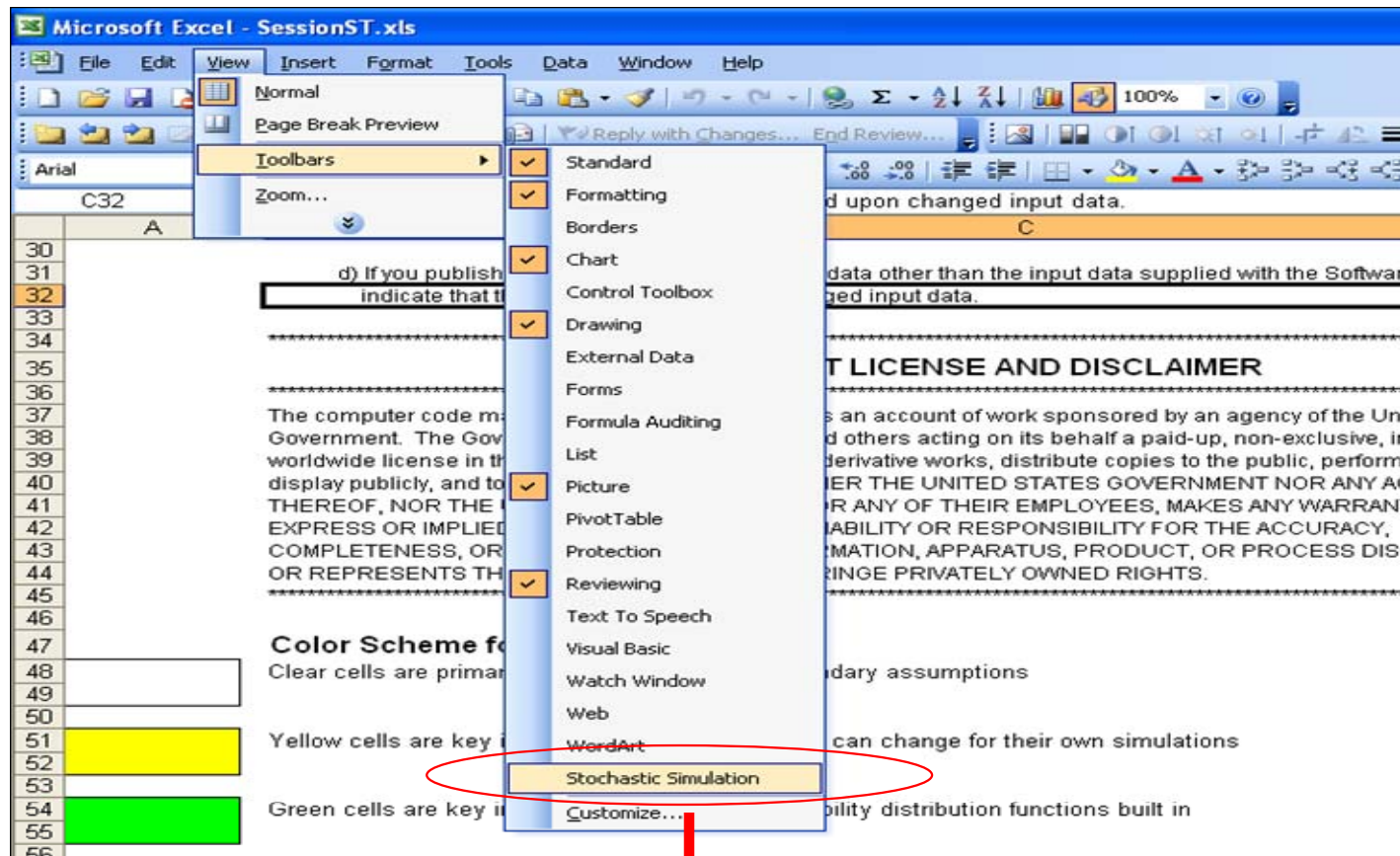
Before Conducting a Stochastic Simulation Run, the user must make sure that a Microsoft Office XP Web Component is installed on your computer:

Go to Windows website (below) to download the file “owc10.exe”:

<http://www.microsoft.com/downloads/details.aspx?FamilyID=982b0359-0a86-4fb2-a7ee-5f3a499515dd&displaylang=en>

When the download is complete, double-click on the file icon and follow the on-screen installation instructions.

Loading the Stochastic Simulation Tool into GREET



Stochastic Simulation

Cell Input Sampling Forecast Cells Run Simulation Delete Distribution

For those users could not find the stochastic simulation tool in the *toolbars*, you'll need to go to *Tools>Add-Ins>Browse>* to reload the file "STOCHASTIC.xla", which is in the GREET1.7 folder.

Select YES prior to a Specific GREET Stochastic Simulation

Scenario Control Variables and Input Assumptions

1. Selection of Simulation Options for Simulation

1.1) Target Year for Simulation

2010

1.2) Point-Estimation or Probability-Estimation Option

yes ... To run probability-based simulations
no ... Not to run probability-based simulations (instead, to run point-estimation simulations)

1.3) Time Series Simulation Option

1 -- GREET default time-series (TS) values; 2 -- User inputs (adjust all years in TS Tables); 3 -- User inputs (adjust future years only)

2. Selection of Vehicle Types for Simulation

1 -- Passenger Cars
2 -- Light-Duty Trucks 1
3 -- Light-Duty Trucks 2

	O2 content by wt.	Oxygenate type	Sulfur level, ppm	Refining Efficiency
Conventional Gasoline	0.0%	5	26	86.0%
RFG: Gasoline Blendstock	2.3%	4	26	85.5%
CARFG: Gasoline Blendstock	2.0%	4	11	85.5%

3.2.c) Ethanol Production Options for Gasoline if ETBE or Ethanol Is Selected as the Oxygenate

	Corn	Woody Biomass	Herbaceous Biomass
Share of Ethanol Feedstock	100.0%	0.0%	0.0%

3.3) Diesel and Other Petroleum-Based Fuel Options

3.3.a) Share of Low-Sulfur Diesel in Total Diesel Use, by volume

100%

5-year period	CG Refining Efficiency	Relative Efficiency (to yr 2010)
1990	86.5%	100.6%
1995	86.5%	100.6%
2000	86.0%	100.0%
2005	86.0%	100.0%
2010	86.0%	100.0%
2015	86.0%	100.0%
2020	85.5%	99.4%

The cells with distribution curve (in green in GREET) and mean value of the distribution curve (immediately above the green cell, which is used to adjust the default curve) are linked to the calculating cell ONLY AFTER you select YES in section 1.2 in the Inputs sheet.

The Steps to Conduct a Stochastic Simulation Run

- **Assign probability distribution functions to the input variables**
- **Specify the number of samples required and the sampling technique**
- **Define the forecast variables**
- **Propagate the uncertainties**
- **Statistically analyze the outputs**

The Stochastic Simulation Tool Contains Eleven Probability Distribution Functions For a New Variable

Distributions

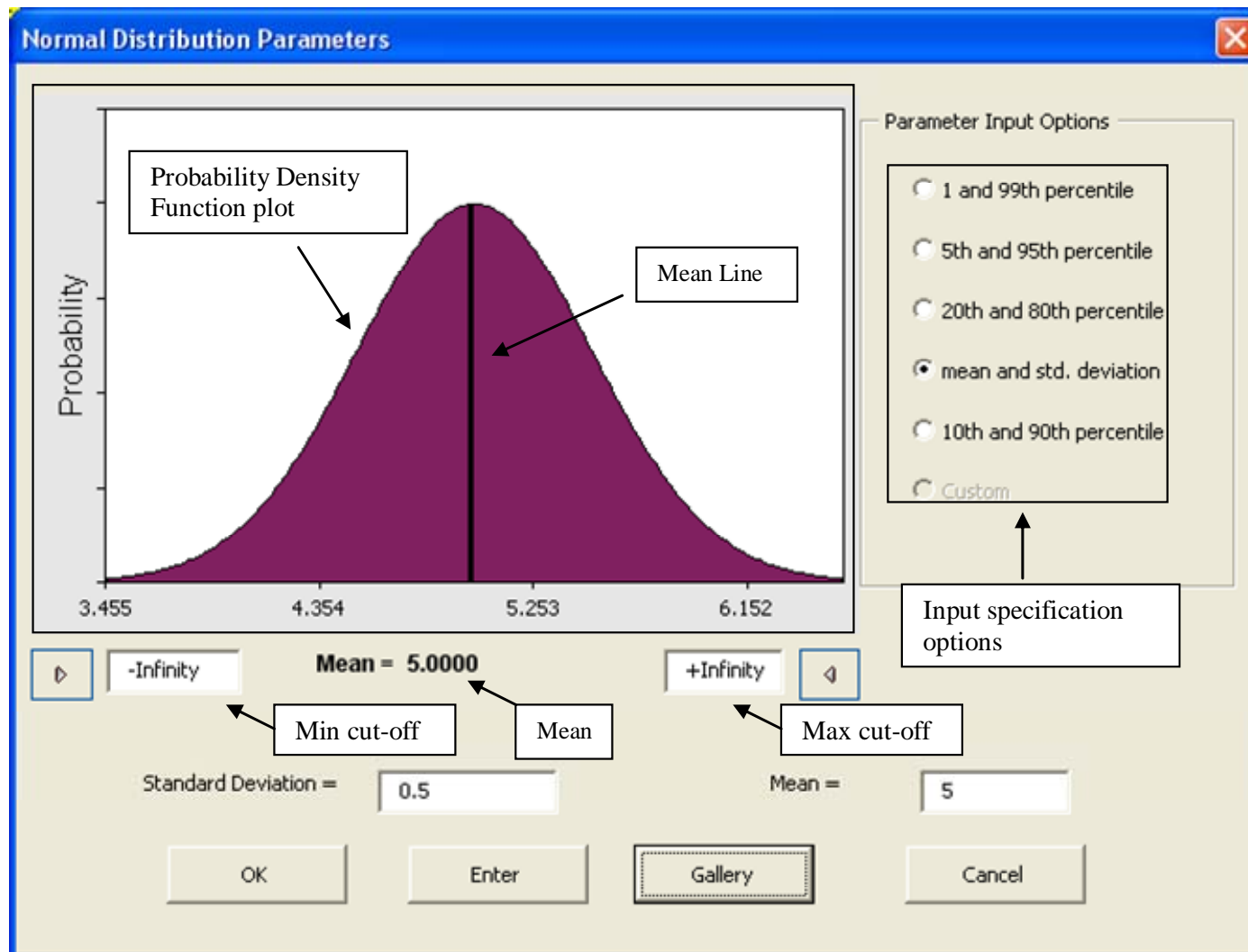
☐ Normal ☐ Lognormal ☐ Uniform ☐ Triangular

☐ Weibull ☐ Beta ☐ Gamma ☐ Extreme Value

☐ Exponential ☐ Pareto ☒ Logistic

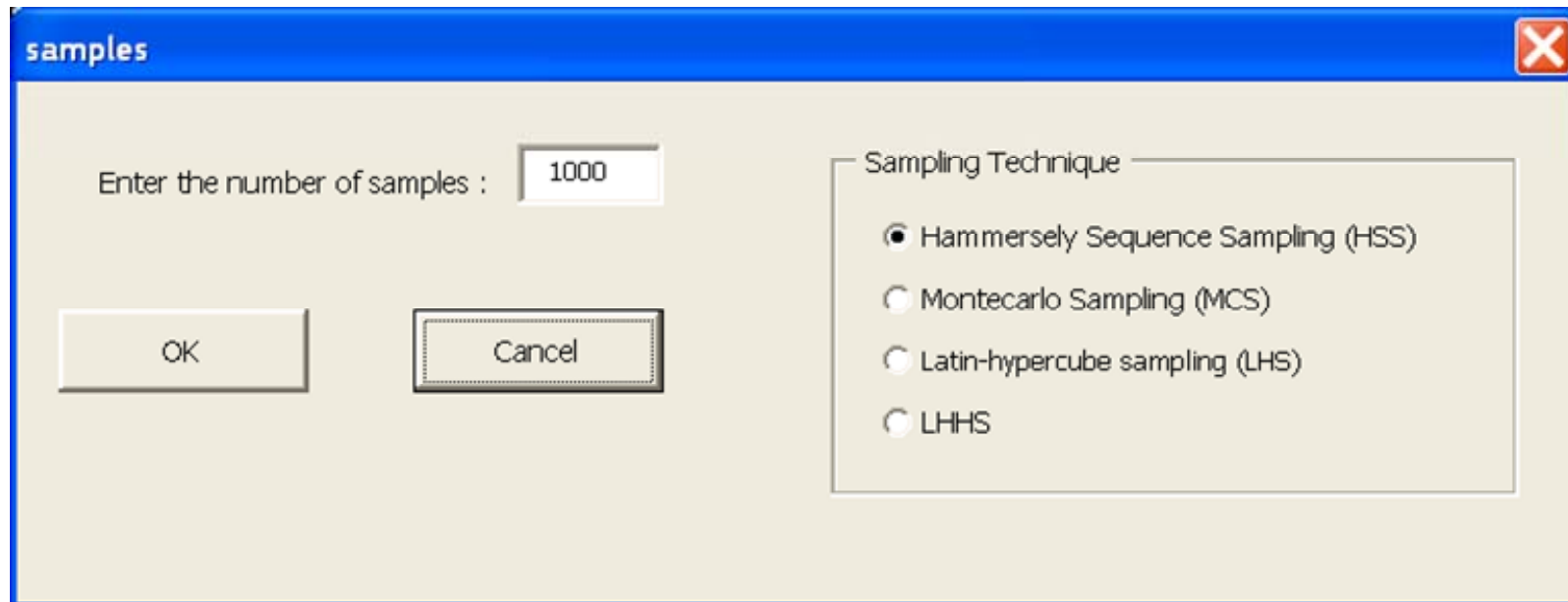
OK Cancel Help

An Example of Input Parameter Specification Window for the Normal Distribution



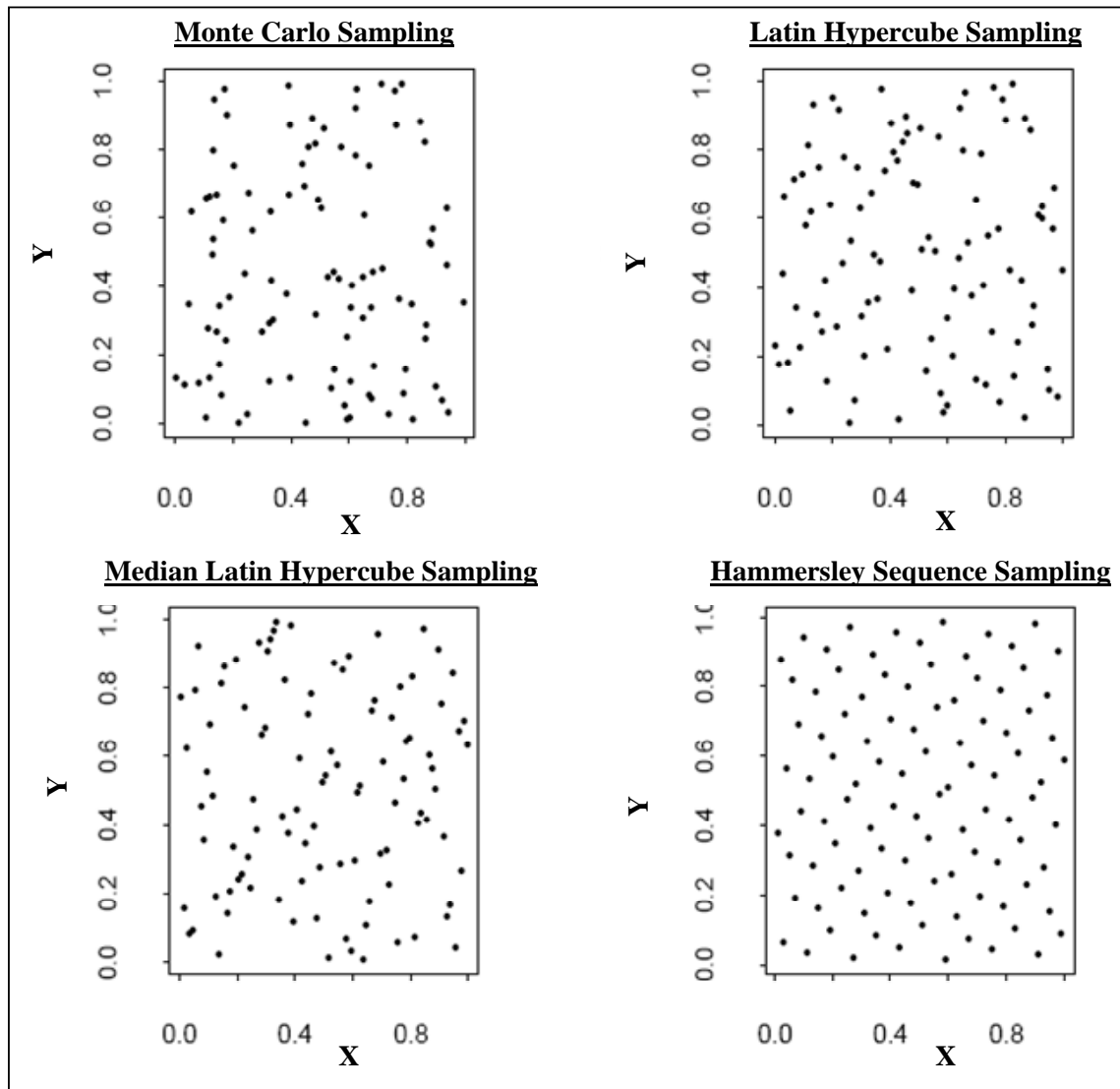
The Stochastic Simulation Tool Incorporates Four Sampling Techniques

- Monte Carlo Sampling (MCS)
- Median Latin Hypercube Sampling (MLHS)
- Hammersley Sequence Sampling (HSS)
- Latin Hypercube Hammersley Sampling (LHHS)



The screenshot shows a dialog box titled "samples" with a standard Windows-style title bar (blue with a red close button). The dialog has a light beige background. On the left, there is a label "Enter the number of samples :" followed by a text input field containing the value "1000". Below this are two buttons: "OK" and "Cancel". On the right, there is a section titled "Sampling Technique" which contains four radio button options: "Hammersely Sequence Sampling (HSS)" (which is selected), "Montecarlo Sampling (MCS)", "Latin-hypercube sampling (LHS)", and "LHHS".

The Number of Samples for Each Sampling Technique Needs to Be Determined Carefully



Define the Forecast Variables: 1) Select Vehicle Technologies

The screenshot shows a software window titled "Forecast Definition". It contains a "Vehicle Types" list on the left with nine items, each preceded by an unchecked checkbox. In the center is a large empty box labeled "Selected Forecasts". To its right is another empty box labeled "Deleted Forecasts". Between these two boxes are two buttons: "<= Add" and "Remove =>". At the bottom are four buttons: "Add Selected forecasts to list", "OK", "Cancel", and "Clear All Forecasts". Annotations with arrows point to these elements: "Vehicle Types" points to the list; "List of selected forecasts" points to the "Selected Forecasts" box; "List of deleted forecasts" points to the "Deleted Forecasts" box; "To add selected forecasts to the list" points to the "Add Selected forecasts to list" button; and "Delete all the forecasts" points to the "Clear All Forecasts" button.

Forecast Definition

Vehicle Types

- ☐ Battery-Powered Electric Vehicles
- ☐ Compression-Ignition Direct Injection Vehicles
- ☐ Compression-Ignition Direct Injection Hybrid Electric Vehicles: Grid Independant
- ☐ Spark-Ignition Hybrid Electric Vehicles: Grid Connected
- ☐ Compression-Ignition Direct Injection Hybrid Electric Vehicles: Grid Connected
- ☐ Spark-Ignition Hybrid Electric Vehicles: Grid Independant
- ☐ Spark-Ignition Direct Injection Vehicles
- ☐ Conventional Spark-Ignition Vehicles
- ☐ Fuel Cell Vehicles

Selected Forecasts

Deleted Forecasts

<= Add

Remove =>

Vehicle Types

List of selected forecasts

List of deleted forecasts

Add Selected forecasts to list

OK

Cancel

Clear All Forecasts

To add selected forecasts to the list

Delete all the forecasts

Define the Forecast Variables: 2) Select Fuel Types and 3) Select Energy/Emission Items

UserForm1

Fuel Types

- ☐ Re-Formulated / Conventional Gasoline
- ☐ California Re-Formulated Gasoline
- ☐ E10
- ☐ Compressed Natural Gas (Dedicated)
- ☐ Liquid Natural Gas (Dedicated)
- ☐ Liquefied Petroleum Gas (Dedicated)
- ☐ Gaseous Hydrogen
- ☐ Liquid Hydrogen
- ☐ M90 (Dedicated)
- ☐ E90 (Dedicated)
- ☐ E85 Flexible Fuel
- ☐ M85 Flexible Fuel
- ☐ Compressed Natural Gas (bi-fuel)

Forecast Definition Options

☒ WTW Forecast Cells

Energy and Emission for WTW forecast

- ☒ Energy Forecast Cells
- ☒ GHGs Forecast Cells
- ☐ Criteria Pollutant (Total) Forecast Cells
- ☐ Criteria Pollutant (Urban) Forecast Cells

☒ WTP Forecast Cells

Energy and Emission for WTP forecast

- ☒ Energy Forecast Cells
- ☒ GHGs Forecast Cells
- ☐ Criteria Pollutant (Total) Forecast Cells
- ☐ Criteria Pollutant (Urban) Forecast Cells

OK Cancel

Define the Forecast Variables: 4) Add or Remove Individual Forecast Variables

Forecast Definition

Vehicle Types

- ☐ Battery-Powered Electric Vehicles
- ☒ Compression-Ignition Direct Injection Vehicles
- ☐ Compression-Ignition Direct Injection Hybrid Electric Vehicles: Grid Independant
- ☐ Spark-Ignition Hybrid Electric Vehicles: Grid Connected
- ☐ Compression-Ignition Direct Injection Hybrid Electric Vehicles: Grid Connected
- ☒ Spark-Ignition Hybrid Electric Vehicles: Grid Independant
- ☐ Spark-Ignition Direct Injection Vehicles
- ☐ Conventional Spark-Ignition Vehicles
- ☐ Fuel Cell Vehicles

Selected Forecasts

Sheet	Cell	Name
Results	\$E\$427	CIDI-DME-WTW-Total Energy
Results	\$E\$428	CIDI-DME-WTW-Fossil Fuels
Results	\$E\$429	CIDI-DME-WTW-Petroleum
Results	\$E\$430	CIDI-DME-WTW-CO2
Results	\$E\$431	CIDI-DME-WTW-CH4
Results	\$E\$432	CIDI-DME-WTW-N2O
Results	\$E\$433	CIDI-DME-WTW-GHGs
Results	\$AN\$139	CIDI-DME-WTW Changes-Total Energy
Results	\$AN\$139	CIDI-DME-WTW Changes-Fossil Fuels
Results	\$AN\$139	CIDI-DME-WTW Changes-Petroleum
Results	\$AN\$139	CIDI-DME-WTW Changes-CO2
Results	\$AN\$139	CIDI-DME-WTW Changes-CH4
Results	\$AN\$139	CIDI-DME-WTW Changes-N2O
Results	\$AN\$139	CIDI-DME-WTW Changes-GHGs
Results	\$E\$490	CIDI-EDIESEL-WTW-Total Energy
Results	\$E\$491	CIDI-EDIESEL-WTW-Fossil Fuels
Results	\$E\$492	CIDI-EDIESEL-WTW-Petroleum
Results	\$AQ\$139	CIDI-EDIESEL-WTW Changes-Petroleum
Results	\$AQ\$139	CIDI-EDIESEL-WTW Changes-CO2
Results	\$AQ\$139	CIDI-EDIESEL-WTW Changes-CH4
Results	\$AQ\$139	CIDI-EDIESEL-WTW Changes-N2O
Results	\$AQ\$139	CIDI-EDIESEL-WTW Changes-GHGs
Results	\$E\$574	GISIHEV-CNGD-WTW-Total Energy

<= Add

Remove =>

Deleted Forecasts

Sheet	Cell	Name
Results	\$E\$493	CIDI-EDIESEL-WTW-CO2
Results	\$E\$494	CIDI-EDIESEL-WTW-CH4
Results	\$E\$495	CIDI-EDIESEL-WTW-N2O
Results	\$E\$496	CIDI-EDIESEL-WTW-GHGs
Results	\$AQ\$139	CIDI-EDIESEL-WTW Changes-Total Energy
Results	\$AQ\$139	CIDI-EDIESEL-WTW Changes-Fossil Fuels

Add Selected forecasts to list

OK

Cancel

Clear All Forecasts

Statistically Analyzing the Outputs after Each Stochastic Simulation Run Is Required

Microsoft Excel - Book6

File Edit View Insert Format Tools Data Window Help Simulation

Simulation

Run FLUENT Exit FLUENT

Cell Input No. of samples Forecast Cells Run Simulation

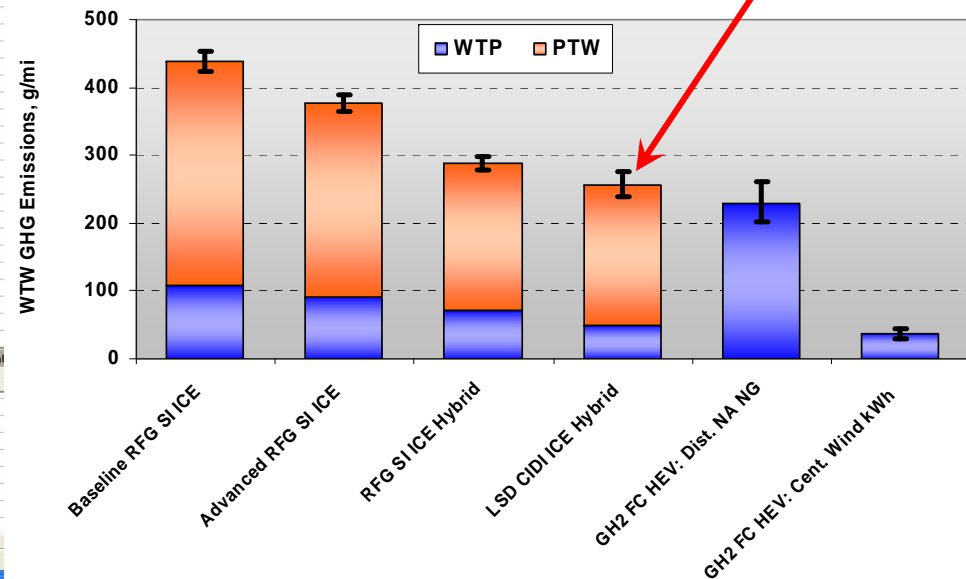
	A	B	C	D	E	F	G	H
		EV-Electricity-WTW-Total Energy	EV-Electricity-WTW-Fossil Fuels	EV-Electricity-WTW-Petroleum	EV-Electricity-WTW-CO2	EV-Electricity-WTW-CH4	EV-Electricity-WTW-N2O	EV-Electricity-WTW-Other
1								
2		3321.399464	2903.273558	104.072573	284.3042485	0.377779647	0.004126539	
3		3163.626235	2765.352496	99.08984517	264.1939072	0.359611648	0.003917362	
4		3079.852945	2692.116244	96.43835883	251.2883063	0.350103763	0.003828103	
5		3238.052196	2830.417478	101.4902298	263.778169	0.3681206	0.00399349	
6		3140.147283	2744.825733	98.35458792	252.1844079	0.357233623	0.003919769	
7		3043.772242	2660.582457	95.3074409	254.6315965	0.346030693	0.003760875	
8		3200.222875	2797.343163	100.2726682	264.5720268	0.363841316	0.003972926	
9		3116.192323	2723.887281	97.57959977	254.5408613	0.35435255	0.003829408	
10		2986.787116	2610.767386	93.50614537	240.9781668	0.339812086	0.003739753	
11		3171.191209	2771.966214	99.33162812	265.7564495	0.3605604	0.003923285	
12								
13	Mean	3146.124589	2750.053201	98.54430814	259.923823	0.357744633	0.003901151	
14	S.D.	96.73637538	84.56405135	3.06244272	11.50163109	0.010987817	0.000116327	
15	P0	2986.787116	2610.767386	93.50614537	240.9781668	0.339812086	0.003739753	
16	P10	3038.07373	2655.60095	95.12731134	251.0637838	0.345408833	0.003758762	
17	P20	3072.636804	2685.809487	96.21217524				
18	P30	3105.290509	2714.35597	97.23722749				
19	P40	3130.565299	2736.450352	98.04459266				
20	P50	3151.887759	2755.089115	98.72221654				
21	P60	3166.653425	2767.997983	99.18655835				
22	P70	3179.900709	2779.579299	99.61394014				
23	P80	3207.78874	2803.958026	100.5161805				
24	P90	3246.386923	2837.703086	101.7494646				
25	P100	3321.399464	2903.273558	104.0725773				
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Stochastic Simulation

Cell Input: Sampling

Step 1: the stochastic simulate tool will automatically generate the results for each sample after the run is completed .

Step 3: with the statistical results, the user may manually draw graphs (e.g., the uncertainty range between the P10 and P90 values in the demo chart below).



It may take several minutes to more than an hour to finish a particular stochastic simulation run depending on many factors, such as the number of forecast cells selected, the number of samples selected, and the hardware configuration of your computer.